If we assume the steering angle $\delta$ is small:

$$u = \begin{bmatrix} \delta \\ F \end{bmatrix}, \quad s_1 = \begin{bmatrix} y \\ \dot{y} \\ \psi \\ \dot{\psi} \end{bmatrix}, \quad s_2 = \begin{bmatrix} x \\ \dot{x} \end{bmatrix}$$

$$\dot{\dot{y}} = -\dot{\psi}\dot{x} + \frac{2C_\alpha}{m}\left(\cos\delta\left(\delta - \frac{\dot{y}+l_f\dot{\psi}}{\dot{x}}\right)\right) - \frac{2C_\alpha \dot{y}}{m\dot{x}} - \frac{l_r\dot{\psi}}{m\dot{x}} \quad (\cos\delta \approx 1)$$

$$= -\dot{\psi}\dot{x} + \frac{2C_\alpha}{m}\delta - \frac{2C_\alpha \dot{y}}{m\dot{x}} + \frac{2C_\alpha l_f \dot{\psi}}{m\dot{x}} - \frac{2C_\alpha \dot{y}}{m\dot{x}} - \frac{2C_\alpha l_r \dot{\psi}}{m\dot{x}}$$

$$= \dot{y}\left(-\frac{2C_\alpha}{m\dot{x}} - \frac{2C_\alpha}{m\dot{x}}\right) + \dot{\psi}\left(-\dot{x} - \frac{l_r}{m\dot{x}} + \frac{2C_\alpha l_f}{m\dot{x}}\right) + \delta\left(\frac{2C_\alpha}{m}\right)$$

$$= \dot{y}\left(-\frac{4C_\alpha}{m\dot{x}}\right) + \dot{\psi}\left(-\dot{x} + \frac{-2C_\alpha l_r + 2C_\alpha l_f}{m\dot{x}}\right) + \delta\left(\frac{2C_\alpha}{m}\right)$$

$$\dot{\dot{\psi}} = \frac{2l_f C_\alpha}{I_z}\delta - \frac{2l_f C_\alpha \dot{y}}{I_z\dot{x}} - \frac{2l_f^2 \dot{\psi} C_\alpha}{I_z\dot{x}} + \frac{2l_r C_\alpha \dot{y}}{I_z\dot{x}} - \frac{2l_r^2 C_\alpha \dot{\psi}}{I_z\dot{x}}$$

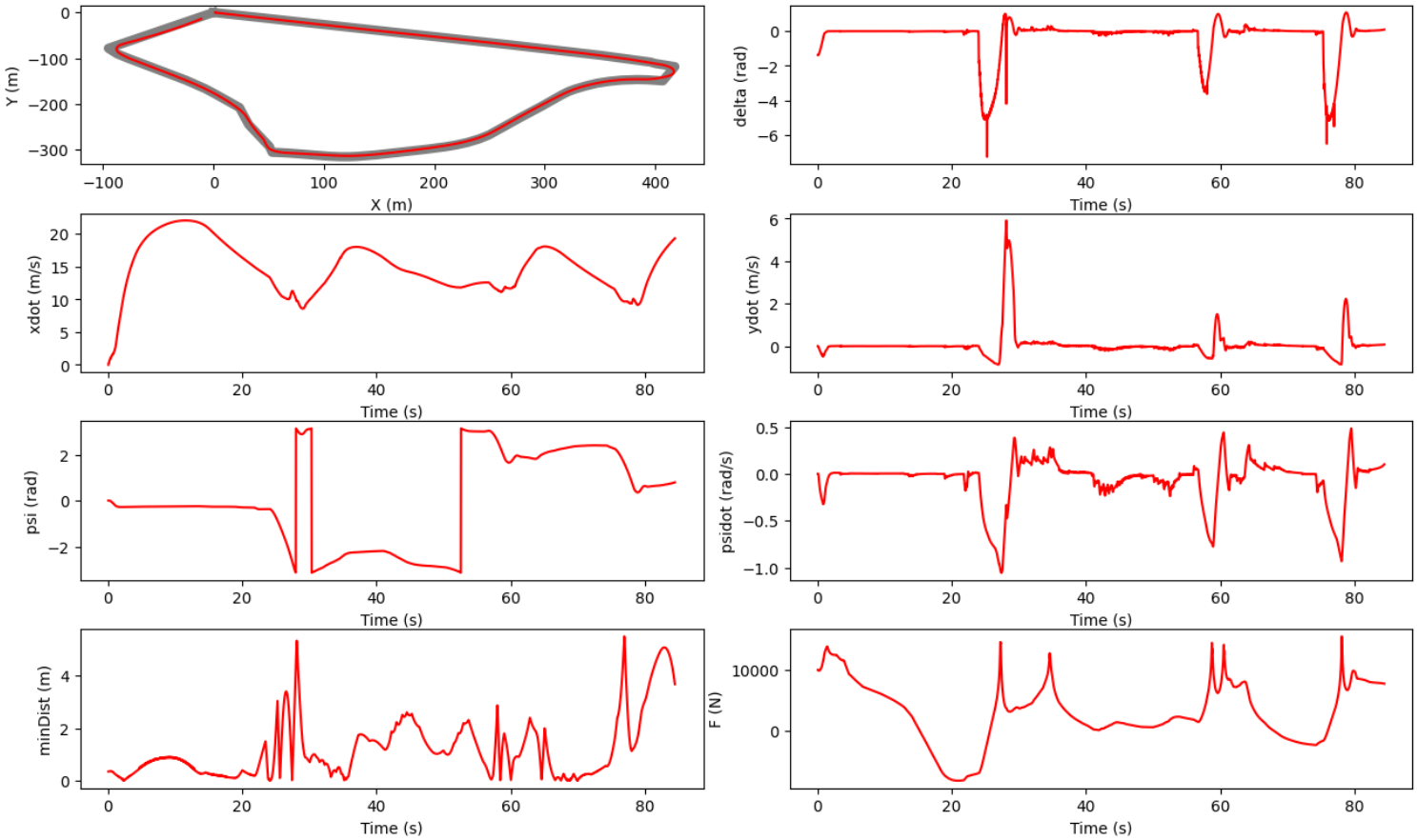
$$= \dot{y}\left(\frac{2l_r C_\alpha - 2l_f C_\alpha}{I_z\dot{x}}\right) + \dot{\psi}\left(-\frac{2l_f^2 C_\alpha + 2l_r^2 C_\alpha}{I_z\dot{x}}\right) + \left(\frac{2l_f C_\alpha}{I_z}\right)\delta$$

So the linearized equation is:

$$\dot{s}_1 = \begin{bmatrix} 0 & 1 & 0 & 0 \\ 0 & -\frac{4C_\alpha}{m\dot{x}} & 0 & -\dot{x} + \frac{-2C_\alpha l_r + 2C_\alpha l_f}{m\dot{x}} \\ 0 & 0 & 0 & 1 \\ 0 & \frac{2l_r C_\alpha - 2l_f C_\alpha}{I_z\dot{x}} & 0 & -\frac{2l_f^2 C_\alpha + 2l_r^2 C_\alpha}{I_z\dot{x}} \end{bmatrix} \begin{bmatrix} y \\ \dot{y} \\ \psi \\ \dot{\psi} \end{bmatrix} + \begin{bmatrix} 0 & 0 \\ \frac{2C_\alpha}{m} & 0 \\ 0 & 0 \\ \frac{2l_f C_\alpha}{I_z} & 0 \end{bmatrix} \begin{bmatrix} \delta \\ F \end{bmatrix}$$

$$\ddot{x} = \dot{\psi}\dot{y} + \frac{F}{m} - fg$$

$$\dot{s}_2 = \begin{bmatrix} 0 & 1 \\ 0 & 0 \end{bmatrix} \begin{bmatrix} x \\ \dot{x} \end{bmatrix} + \begin{bmatrix} 0 & 0 \\ 0 & \frac{1}{m} \end{bmatrix} \begin{bmatrix} \delta \\ F \end{bmatrix} + \dot{\psi}\dot{y} - Fg$$




Score for completing the loop: 30.0/30.0
Score for Score for completing the loop: 30.0/30.0
Score for average distance: 30.0/30.0
Score for maximum distance: 30.0/30.0
Your time is  84.44800000000001
Your total score is : 100.0/100.0
total steps:  84448
maxMinDist:  5.4831341545966525
avgMinDist:  1.2185331031845643